PRELIMINARY REPORT ON GEOARCHAEOLOGICAL RESEARCH IN WEST SAQQARA

Jerzy Trzciński, Kamil O. Kuraszkiewicz, Fabian Welc

Previous geological research in the area (including sedimentological and petrographical analyses) has demonstrated its usefulness for in-depth archaeological investigations conducted in the necropolis of west Saqqara (Mycielska-Dowgiałło and Woronko 1998: 106–115). An examination of rock layers reveals, among others, the geomorphological processes that shaped the natural environment at the time (Mycielska-Dowgiałło and Woronko 1999: 107–112). The layers which are the effect of these processes and the ancient topography are closely interrelated with archaeological features observed in the examined part of the Saqqara necropolis. Indeed, one observes distinctly the impact distribution of rock units and geomorphological processes exerted on human activities in the necropolis during its functioning (Mycielska-Dowgiałło, Szafrański and Woronko 1999: 167–178).

GEOARCHAEOLOGICAL AND GEOMORPHOLOGICAL INVESTIGATIONS IN THE NECROPOLIS

In the 2007 season, comprehensive geoarchaeological and geomorphological research was carried out, concentrating on the examination of exposures (sections) from both earlier and current fieldwork. The chief objective of the examination was to identify genetically individual rock layers and to determine their age, as well as reconstruct ancient topography and climate. In the end it proved possible to establish the relations between geomorphology and the geological and archaeological layers in the excavated area.

The present research included the following:

— geomorphological analysis of the excavated area and immediately adjacent ground,

— geological research on exposures in the excavated area (sedimentological, petrographical analyses),

— field documentation of the exposures.

The research was carried out at the southeastern edge of the excavated area (squares 2001, 2002, 2101, 2102; for location of squares on the site plan, cf. Myśliwiec *et alii* 2004: Pls I, II, IV) in the immediate vicinity of the foundation of the Netjerykhet enclosure wall. Altogether 14 exposures were analyzed in this area [*Figs 1, 2*]. Two new exposures were also examined in the northern part of the excavated area (squares 1804, 1805 and 1907) [*Figs 3, 4–5*]. A lithostratigraphic profile of these analyses was prepared. The relations between natural and anthropogenic layers were determined taking into account their chronology.

Moreover, a preliminary analysis was carried out of the rock layers in the cleared burial shafts in order to trace the dependence between geological bedrock structure and the techniques used to cut such shafts. The fill inside the shafts was also examined in detail, providing additional data necessary for a reconstruction of climatic conditions in the area of the necropolis in historical periods.

The results justify further compre-hensive geoarchaeological and geomorphological research in the area excavated by the Polish mission in West Saqqara. New data will answer many questions from the borderland of geology and archaeology in the region, including:

— the origins and age of geological deposits and landforms,
— reconstruction of geomorpholo-gical processes shaping the area of the necropolis,
— lithostratigraphic profile of natural and anthropogenic layers from the excavated area.

The results of this research will lead to a paleoclimatic and paleogeographic reconstruction of the natural environment in the context of human activities in the area of the necropolis.

DESCRIPTION OF THE EXPOSURES

Geoarchaeological research carried out in 2007 on layers uncovered in squares 2001, 2002, 2101, 2102, 1804, 1805, 1907 [cf *Figs 1–5*] was aimed at reconstructing natural morphodynamic processes, ancient climate and processes of anthropogenic transfor-mation of the area in question during the early and late phases, I and II respectively, of the functioning of the so-called Lower Necropolis (for the stratigraphy and preliminary assessment of the chronology of the Lower Necropolis, see Szafrański 1999; Ćwiek 2000; Kuraszkiewicz 2007; for earlier geoarchaeological research, see Mycielska-Dowgiałło, Woronko 1998; 1999; Mycielska–Dowgiałło, Szafrański, Woronko 1999).

PHASE I (c. 2700–2600 BC)

In squares 2001 and 2002 [*Fig. 1*], the area investigated extended from the stone foundation of the Step Pyramid enclosure wall (of Third Dynasty date) in the east to Shafts 63 and 101 (from the Late Old Kingdom) in the west. A sequence of natural strata was revealed, as well as strata of anthropogenic nature (see exposures nos 5, 6, 6a, 7, *Figs 1, 2*). A thin mud floor (silt, clay and colloid fractions) lay directly on bedrock, which is a local type of Eocene limestone designated as the Saqqara Member of the Maadi Formation (cf. Said 1962: 99, 322). This floor (F1) was uncovered to the east of Shafts 63 and 101 (cf. Welc 2009) [*Fig. 6*]. The limestone is heavily eroded and weathered on the surface. Above this is a layer of light gray–red sand and very fine gravel (L1). Superimposed is another mud floor (F2), which was whitewashed. Layer L2, found on top of it, is formed of sand and limestone, the latter both fine and medium angular gravel and very fine rounded gravel. This layer is covered with sand of red color rich in iron (Fe^{3+}) and quartz gravel with cobbles from 1 to 15 cm in diameter; the layer is strongly cemented with calcium carbonate ($CaCO_3$) — this is the so-called *lower red layer* — L3 (Welc 2009: 176, Fig. 4). The next layer, L4, which is of gray–green color, is composed of local limestone (angular, ranging from gravel to boulder), fine rounded gravel of quartz grains, fragments of crushed mud-brick mixed with sand and fine-grained local limestone. Closing this sequence is the so-called *upper red layer* (L5), composed of red

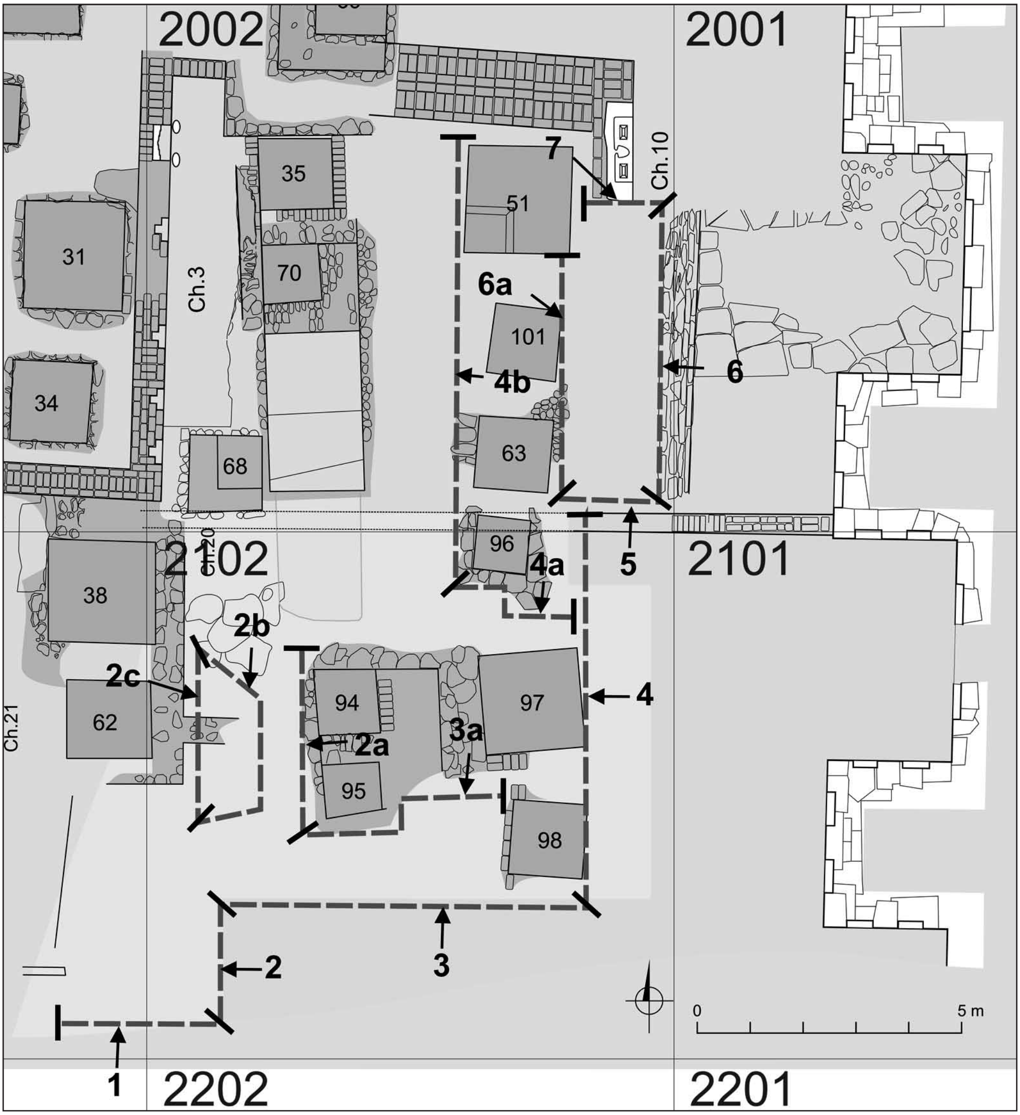


Fig. 1. Area adjoining the foundation of the Netjerykhet enclosure wall examined in 2007: dashed line marks edge exposures, numbers with arrows identify individual exposures (Drawing K.O. Kuraszkiewicz, J. Trzciński)

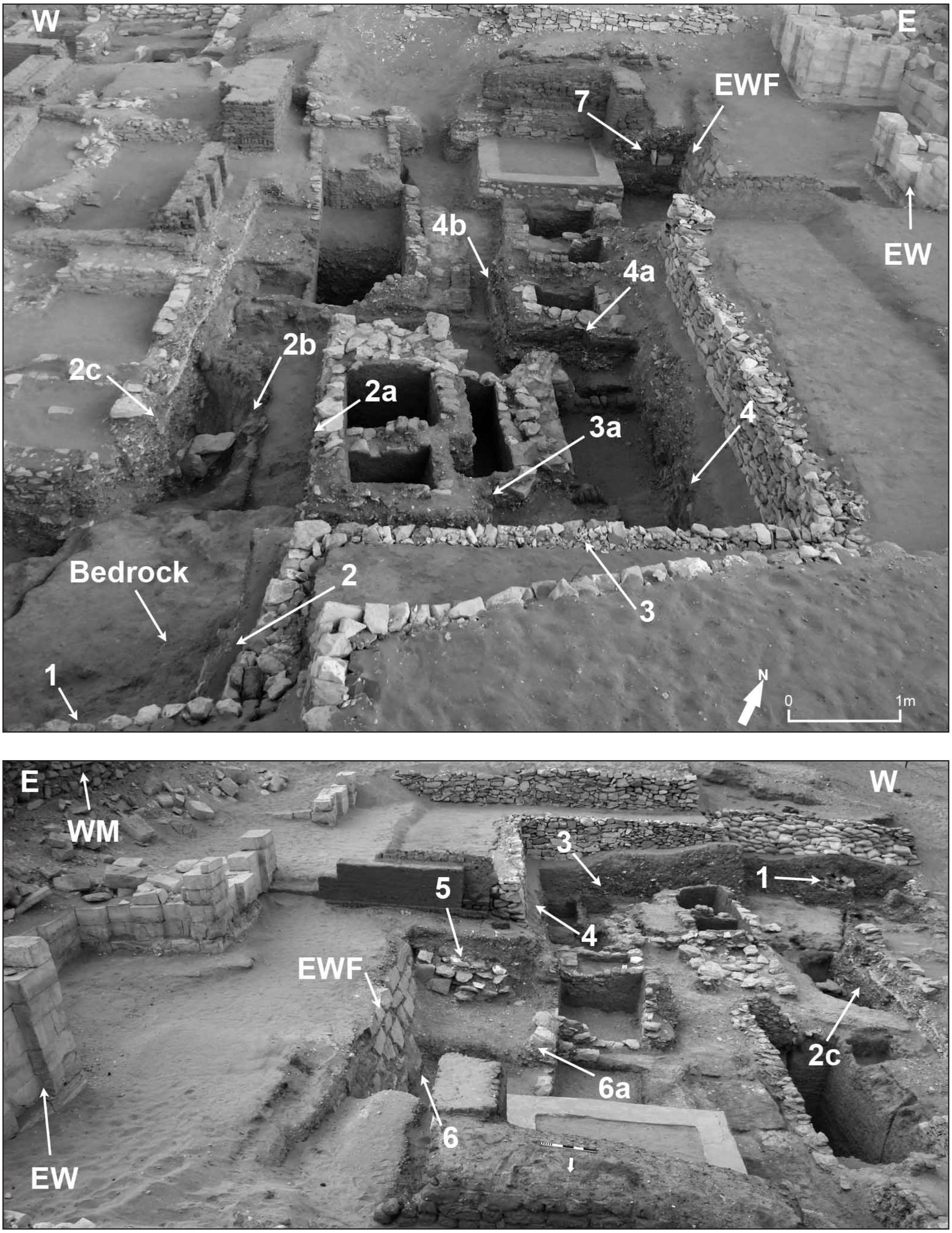
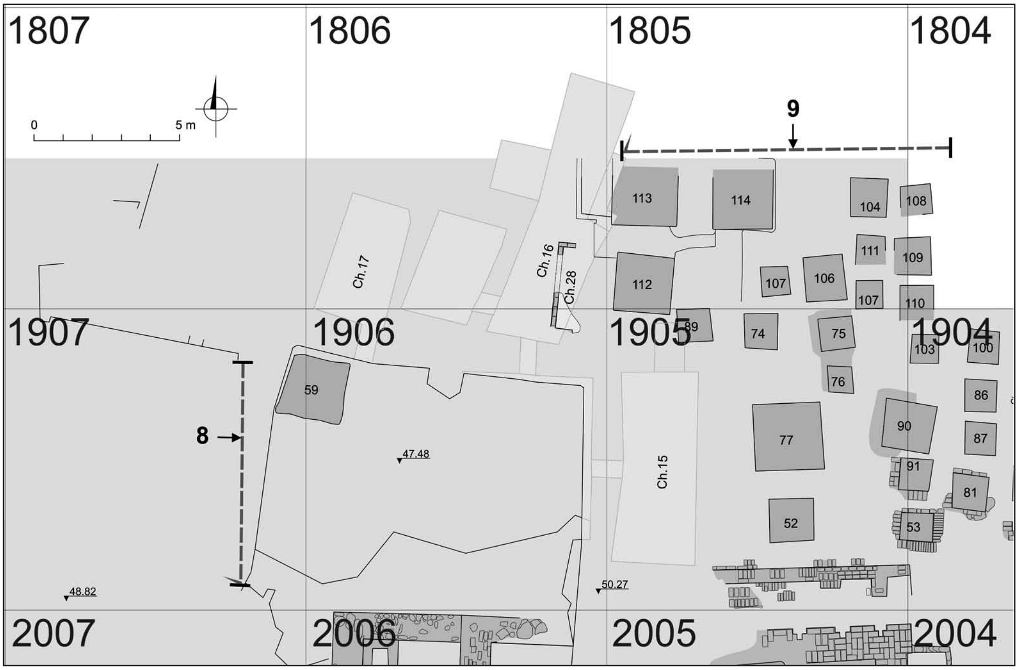
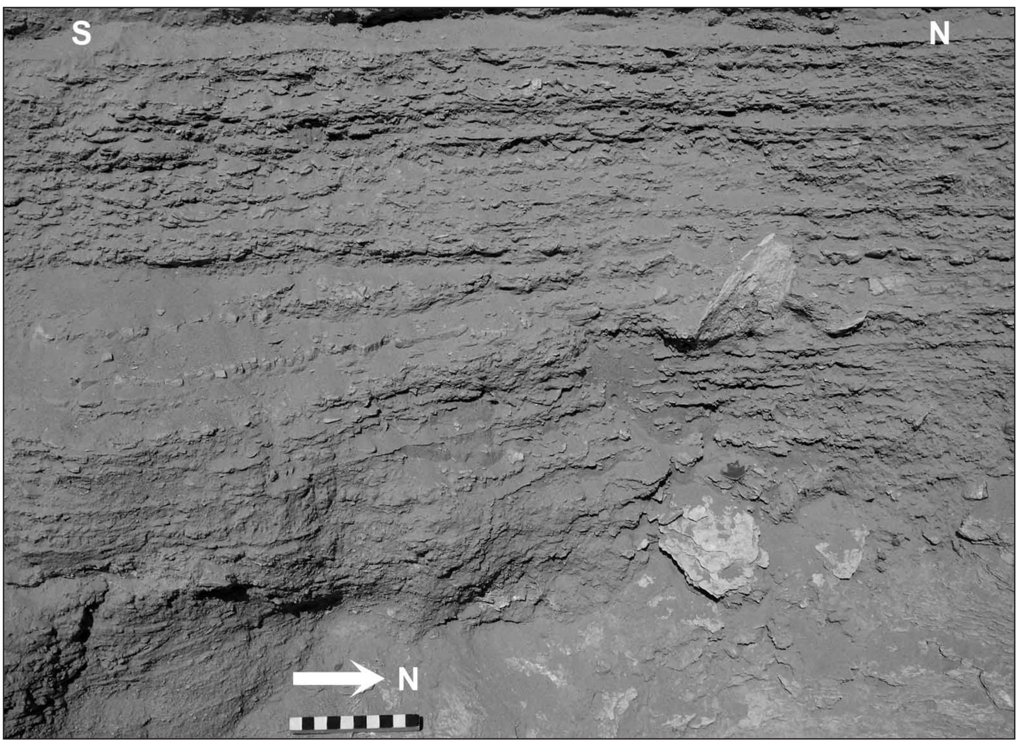


Fig. 2. *Southeastern part of the excavated area covered by geoarchaeological research (exposure numbers from Fig. 1), view from the south (top) and from the north; EWF – Step Pyramid enclosure wall foundation, EW – enclosure wall, WM – Western Massif (Photo J. Dąbrowski, J. Trzciński)*


1807
1806
1805
1804
0
5 m
9
113
114
104
108
111
109
Ch.17
Ch.16
Ch.28
112
107
106
107
110
1907
1906
1905
89
74
75
1904
103
100
59
76
86
8
47.48
90
77
87
Ch.15
91
81
52
53
48.82
50.27
2007
2006
2005
2004


S
N
N

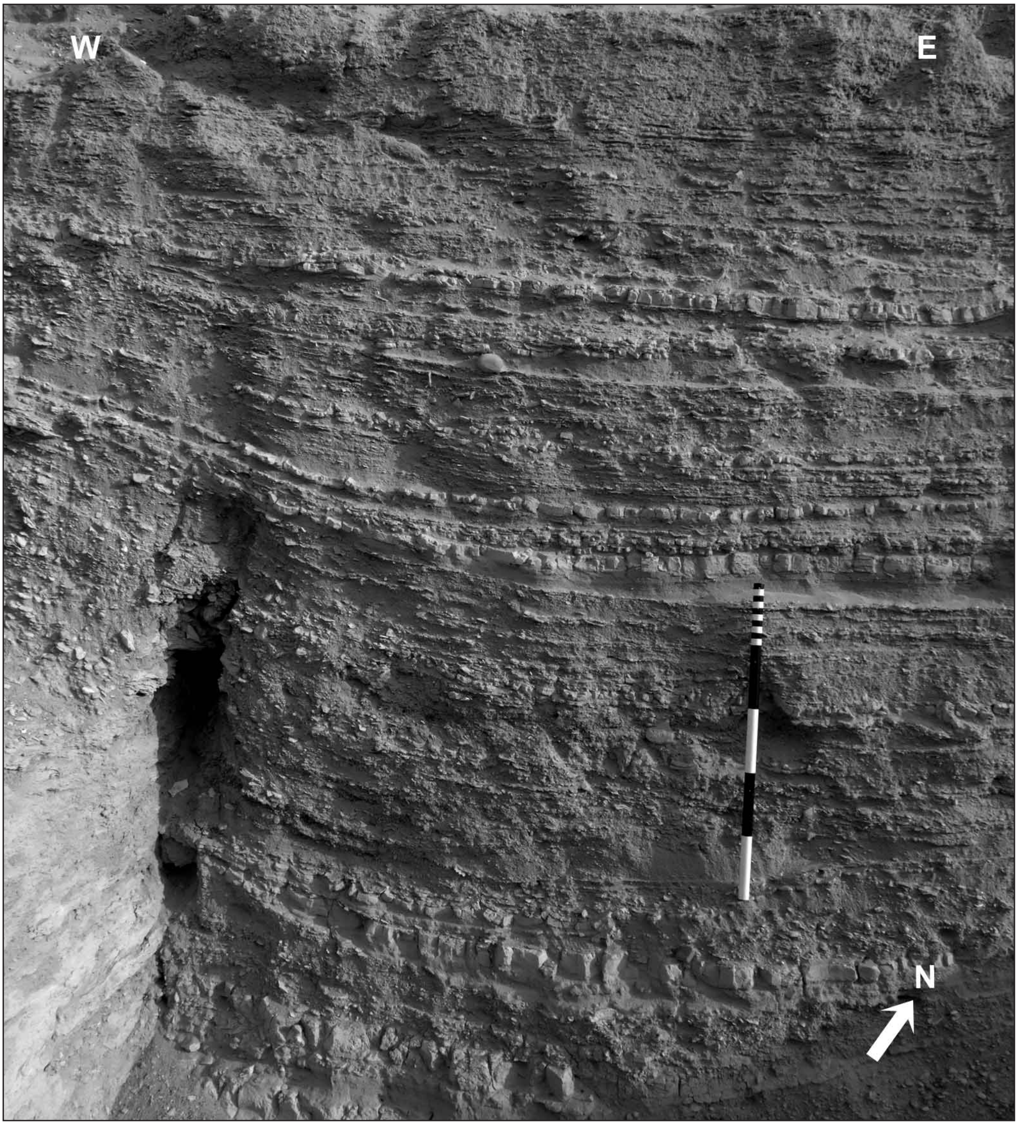
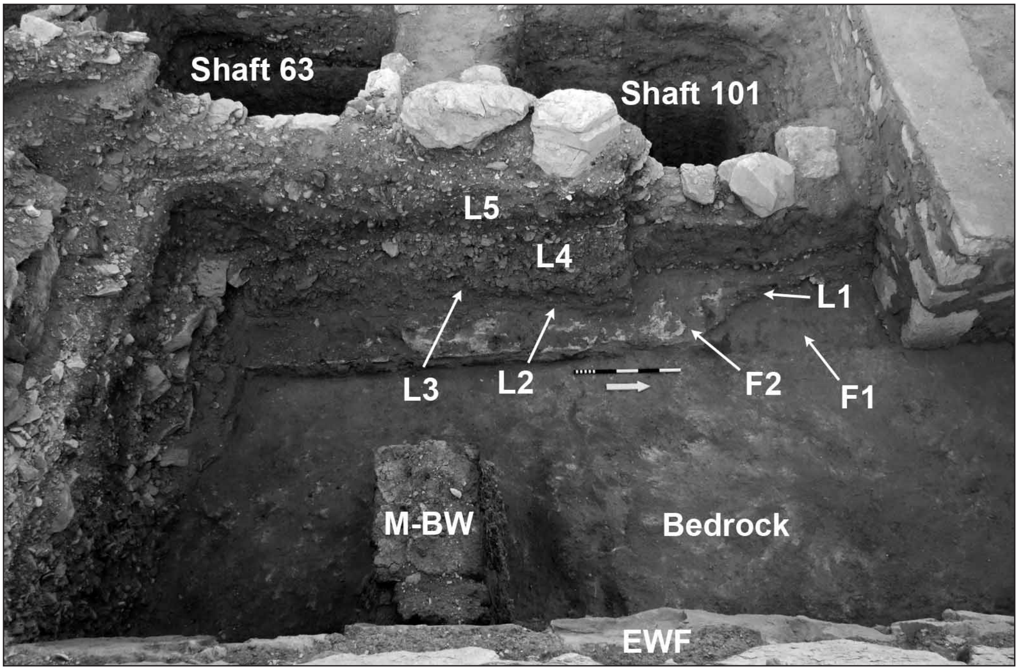


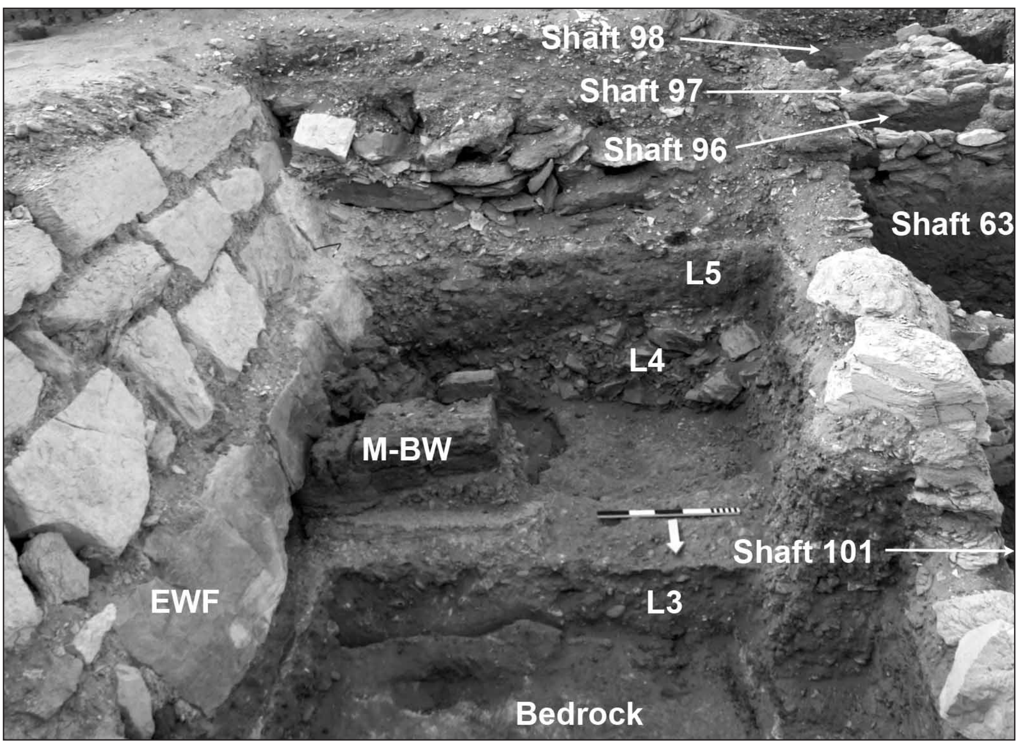
Fig. 5. Part of exposure no. 9 (for location, see Fig. 3), view from the south (Photo F. Welc)

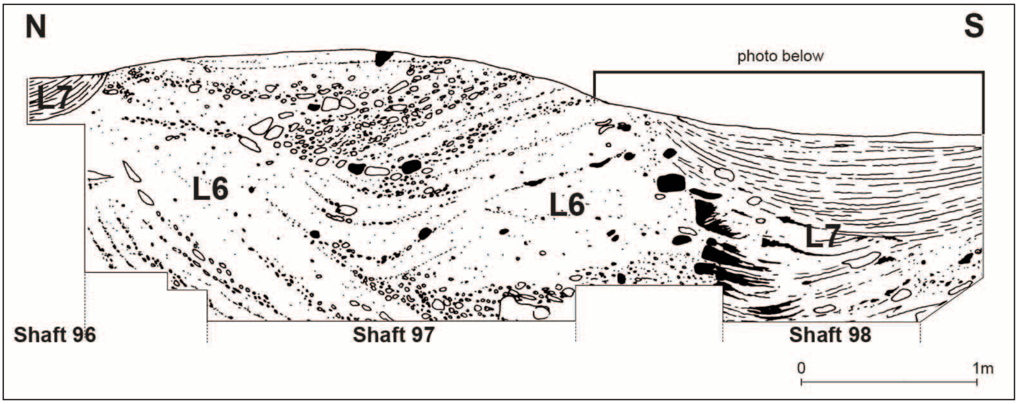
Opposite page:

◀ *Fig. 3. Plan of excavations in the northern part of the necropolis: dashed line marks edge exposures, numbers with arrows identify individual exposures (Drawing K.O. Kuraszkiewicz, J. Trzciński)*

◀ *Fig. 4. Part of exposure no. 8 (for location, see Fig. 3), view from the east (Photo J. Trzciński)*


Shaft 63
Shaft 101
L5
L4
L1
L3
L2
F2
F1
M-BW
Bedrock
EWF


Shaft 98
Shaft 97
Shaft 96
Shaft 63
L5
L4
M-BW
Shaft 101
EWF
L3
Bedrock



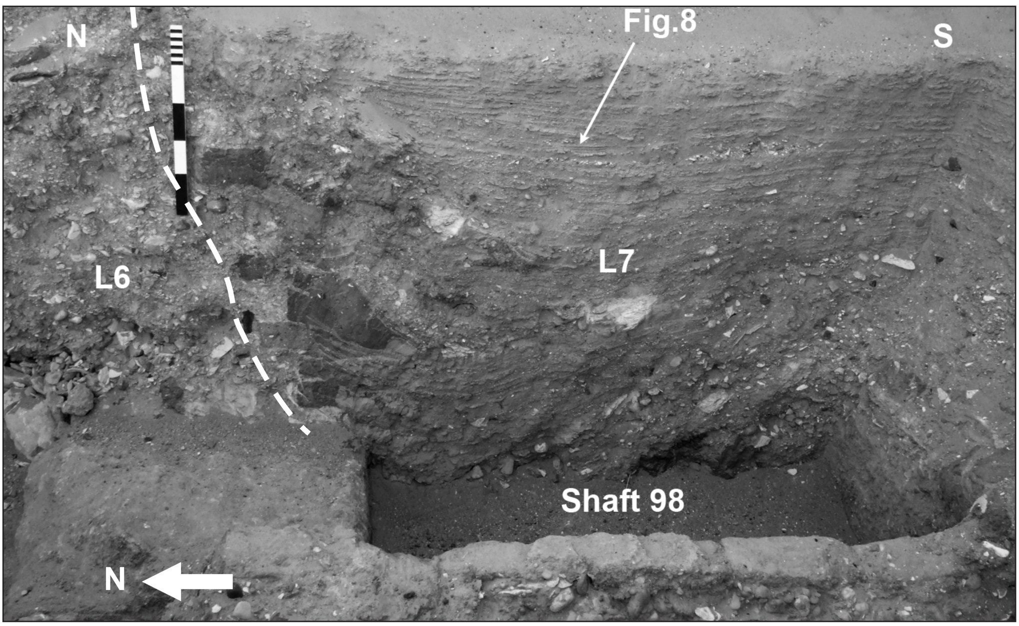


Fig. 7. *Sequence of strata in exposure no. 4 in squares 2101 and 2102 (see Figs 1, 2) above Shafts 96, 97 and 98, view from the west: L6 – layer no. 6, L7 – layer no. 7, description of layers in the text; photo shows the section above shaft 98, arrow indicates spot where a fragment of the upper surface of the lamina shown in Fig. 8 was discovered (Drawing F. Welc, J. Trzciński; photo F. Welc)*

Opposite page:
◀*Fig. 6.* *Sequence of strata in squares 2001 and 2002 next to the foundation, under their level and under the level of the foundations of the Step Pyramid enclosure wall (Third Dynasty), view from the east (top) and north (bottom): F1 – floor no. 1; L1 – layer no. 1; F2 – floor no. 2 (whitewashed); L2 – layer no. 2; L3 – layer no. 3 (lower red layer); L4 – layer no. 4; L5 – layer no. 5 (upper red layer); M-BW – mud-brick wall; EWF – Step Pyramid enclosure wall foundation; description of layers in the text (Photo F. Welc)*

sand rich in iron (Fe^{3+}) cemented with calcium carbonate ($CaCO_3$), featuring embedded quartz gravel with cobbles 1–10 cm in diameter and single angular coarse gravel of limestone up to 3 cm in diameter (Welc 2009: 175–177, Fig. 4). Erected on top of this layer is a mud-brick wall aligned E–W and the stone enclosure wall of the Step Pyramid (Welc 2009: 176–177, Figs 5, 6).

PHASE II (c. 2300–2000 BC)

Exposures nos 4a, 4b [*Figs 1, 2*] in squares 2101 and 2102 show layers L1 through L5 and floor F2 superimposed on bedrock (see description of exposures for Phase I). Directly on bedrock and on top of the fill of shaft 97 there lies layer L6, which takes on a synclinal form, that is, a downward-curving fold with the axis nearer to the northern edge of the shaft [*Fig. 7*]. The layer is composed of local limestone (rounded pebbles, ranging from gravel to boulder) and rounded mud-brick and *tafl* fragments. The cementing material is locally layered sand and silt with fine gravel of limestone. In the southern part of exposure no. 4, that is,

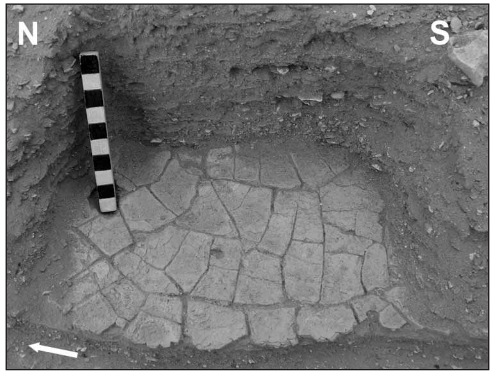


Fig. 8. Top surface of lamina with evident polygonal desiccation cracks showing slightly upturned edges (location of uncovered fragment marked in photo in Fig. 7) (Photo J. Trzciński)

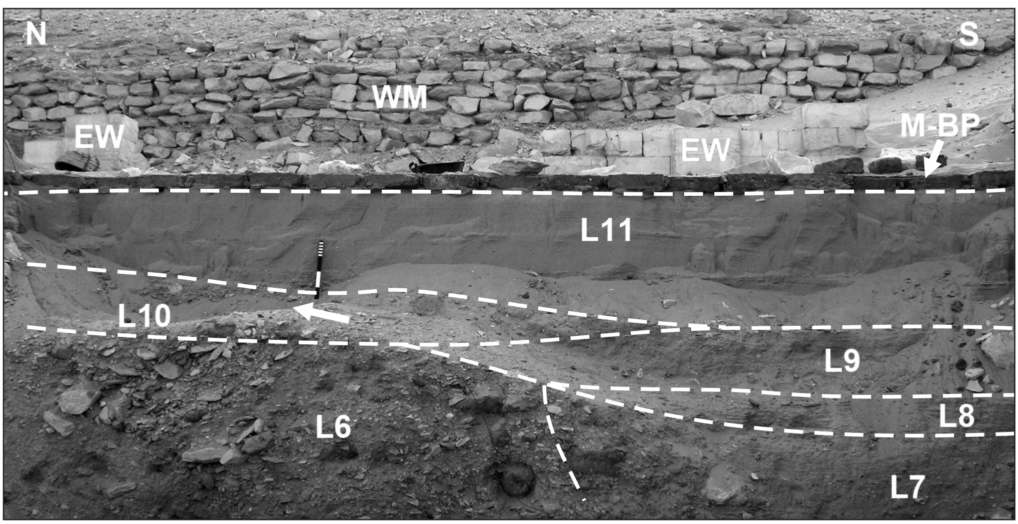


Fig. 9. Sequence of strata in squares 2101 and 2102 above Shafts 96, 97 and 98, view from the west (continuation of section shown in Fig. 7): L6 – layer no. 6; L7 – layer no. 7; L8 – layer no. 8; L9 – layer no. 9; L10 – layer no. 10; L11 – layer no. 11 (description of layers in the text), M-BP – mud-brick platform, EW – enclosure wall, WM – Western Massif (Photo and interpretation J. Trzciński)

above shaft 96, this layer passes horizontally into a laminated sediment with a large content of rounded fine and medium quartz gravel and angular fine and medium limestone (L7). This is also synclinal in form, reaches below the top of Shaft 96 [*Fig. 7*]. The silty–clayey laminated sediment is of varied thickness of laminas, from 1 to 7 cm, thinning toward the top. The lamina surface is often cracked [*Fig. 8*]. The maximum number of laminas is about 80.[1] Above this there is layer L8 which is much more extensive than layer L7, but the character of the sedimentation is the same [*Fig. 9*]. The laminas are thinner, from 1 to 2 cm, containing mostly silty grains. The number of laminas are 30 at the most. The laminas thin away to the north, that is, approximately even with the northern edge of Shaft 97. Superimposed is layer L9 of the same extent, made up of yellow–brown sand characterized by horizontal, parallel layering and a large content of rounded fine quartz gravel, as well as angular and flat coarse gravel of limestone spall. Found at the northern end of the described exposure is layer L10 which is discontinuous with layer L9; it is superimposed directly on the synclinal form of layer L6. It is made up of rounded pebbles of quartz, angular limestone spall and chert mixed with sand and silt of yellowish-gray color. The sequence is covered with fine-grained, horizontally layered yellow sand, which has been designated as layer L11. It is on this sand layer that the mud-brick platform was erected.

INTERPRETATION OF GEOARCHAEOLOGICAL RESULTS

PHASE I

Analysis of the profile and mutual stratigraphic relations of the above layers led to a reconstruction of the geodynamic processes that shaped the natural environment reaching indirectly to human activity in the area. Archaeological interpretation of the findings indicates that these processes could have taken place in the first phase of use of the Lower Necropolis, that is, between 2700 and 2600 BC.

At the beginning of this phase the climate appears to have changed from drier and warmer to cooler and wetter (observations confirmed by earlier geoarchaeological research, cf. Mycielska-Dowgiałło, Woronko, 1999: 111; Mycielska-Dowgiałło, Szafrański, Woronko 1999: 178). The kind of weathering observed on the surface of the limestone points to a warm climate characterized by cyclic periods of humidity and dryness with the latter predominating [cf. *Fig. 2*, top, *Fig. 6*]. Floors F1 and F2, which are the earliest testimony of human activity in this part of the Lower Necropolis, appeared at this time (Welc 2009: 177). Deposits of evidently rain-flow origin found on top of these floors attest to a climate characterized by frequent but moderate rain. Layers L1 and L2 are the result of short-lived rubble flows of low intensity and extent, caused by rainfall. No evident traces of

1 Deposits of a similar character and form, but of smaller size, can be seen also in the northern part of the exposure, directly above the southern edge of the casing wall of Shaft 96 [*Figs 2, 7*] and west of Shaft 98 [*Fig. 2*]; deposits of bigger size were noted in exposures nos 8 and 9 [*Figs 3, 4*].

erosion of the two layers show that the time gap between particular water-flows could not have been extensive.

The structure and lithological composition of layers found above this leave no doubt that the water-flows down the slope became much more intensive in later times. Proof of this is supplied by the strongly cemented structure of the *lower red layer* (L3) [cf. ***Fig. 6***]. The cementing is due to cyclical watering of the layers coupled with intensive evaporation. High iron (Fe^{3+}) content suggests intensive weathering of the primary layers in conditions of a warm and fairly humid environment. Next, water started collecting in hollows in the rock massif, testifying to a distinct intensification of rainfall in the area. Corresponding to this phase is layer L4, which is in essence the bottom of a small reservoir filled with crushed stone brought there by intensive mud and rubble flows. The *upper red layer* (layer L5), which ends the studied sequence of strata attributed to Phase I is no longer as strongly cemented structurally as the *lower red layer* (L3).[2] It means that the intensity of rainfall and water-flows lessened over time. In all likelihood, the latter episode corresponds to the beginnings or the first half of the Third Dynasty.

It can be said in conclusion that the climate during the first phase of the functioning of the cemetery was characterized by considerable changeability; furthermore, repeated cycles of dry periods and periods of intensive rainfall occurred alternately over a relatively short time. This reconstruction of events is confirmed by geoarchaeological research carried out, among others, in the eastern part of the Nile Delta, where it was found that in the said period, that is, around 2600 BC, the level of water in the Nile fluctuated considerably due to an unstable climate characterized by transient periods of high and low rainfall intensity (cf. De Wit 1993: 317).[3]

PHASE II

It is difficult to be sure of the climatic conditions in the time following the Third Dynasty through the end of the Fifth Dynasty, because any strata corresponding to this period were destroyed by the superstructures of Sixth Dynasty mastabas (those of Shafts 51, 101, 63, 96, 97, 98).

Observation and analysis of the stratigraphical sequence in section 4 [***Fig. 7***] in square 2102, permitted a provisional reconstruction of site history at the time of the end of the Lower Necropolis, which is put in the Late Old Kingdom and the beginning of the First Intermediate Period (see above). The building of the enclosure wall of the Step Pyramid on the surface of layer L5 probably stopped for a while the mud and rubble flows engulfing the Lower Necropolis.

Layer L6 is connected most likely with the destruction of the Sixth Dynasty mud-brick mastabas,[4] caused by the extensive

2 Layers L3 and L5 are the result of a redeposition of gravels originating from an active phase of the Nile in the Quartenary period. Gravels of this kind are present in large areas of central Saqqara and around Abusir: Said 1962: 194; El-Qady, Sakamoto, Ushijima 1999: 1093. The nearest area with such gravel occurs in the upper part of the southern face of the southern section of the so-called "dry moat". On this structure, cf., among others, Swelim 1988; 2006; Myśliwiec 2006a.

3 With regard to the entire Near East in a broader time range, that is from 7000 to 4500 BC, this period is referred to as a pluvial, cf. Horowitz 1979.

4 Earlier damage of tomb structures has also been noted in the necropolis (e.g. phase B in Kuraszkiewicz 2007: 174), but it seems that the destruction which resulted in the formation of layer L6 was a cataclysm on an unprecedented scale, which ultimately put an end to the functioning of the Lower Necropolis.

water, mud and rubble streams flowing into this area from the east, that is, from the Netjerykhet complex [cf. *Fig. 7*]. This would also indicate that the enclosure wall of the Step Pyramid was in a state of disrepair at the time. The water with mud and rubble flows filled the hollows in the rock massif, among others the shafts mentioned above. This is suggested by the synclinal depressions above Shaft 97. These phenomena should be connected with the beginning of a rainy period which occurred most likely in the end of the Old Kingdom and the beginning of the First Intermediate Period. There were evidently no new mastabas erected after the formation of this layer, but at least some of the burial shafts were robbed and left open (this sequence of events is especially well attested in the case of Shafts 97 and 98 in square 2102) [*Figs 1, 7*].

The next layer L8, of synclinal laminated deposits indicates the existence in the study area of small-sized land-locked reservoirs where accumulations of fine-grained material formed. The fact that these reservoirs were filled with water indicates that the area was heavily watered and its retention capacity did not allow further infiltration of water into the rock massif. Water collected in existing depressions, and sedimentation occurred in stagnant water. Single lamina, consisting of lower silty and upper clayey layers, were the result of one rainfall cycle and the filling of a reservoir with a water suspension [cf. *Figs 7, 8*]. The thickness of the lamina is indicative of the length and intensity of rainfall, and by the same the intensity of erosion and water-flows. Cracks appeared on the top surfaces of the laminas when the reservoirs dried up, testifying to seasonal periods of intense evaporation. The desiccation cracks are not present in all of the laminas, but they occur a number of times throughout the thickness of the layer. The number of laminas proves the intensity and long-lasting character of rainfall.

Layer L8 is a continuation of layer L7 [cf. *Fig. 9*]. After the existing depressions were filled, shallow reservoirs appeared in nearby low-lying areas over a much larger extent. Layer L8 reflects this process and the thinner lamina are proof that the area of water-filled reservoirs increased rather than that the intensity of rainfall dropped. On the other hand, the smaller overall number of lamina is proof of a decline in rainfall cycles.

Superimposed on layer L8 is layer L9 of well sorted sand of aeolian origin, that is, transported by winds [cf. *Fig. 9*]. The dark brown coloring of the layer indicates also very fine material being carried by the winds, while the coarse material in it suggests heavy storms capable of moving also small rubble and stones. A deposit of this kind attests to a drier and warmer climate characterized by no rainfall accompanying its formation.

The erosional dissection of layers L8 and L9 by the deposit designated as L10, which can be interpreted as a mud and rubble stream, suggests a temporary return of flash floods connected with sudden violent rainstorms [cf. *Fig. 9*]. A stream of this kind ran directly over the synclinal form of layer L6. The surface of the area was subsequently leveled by winds which deposited well-sorted sand. The light color and absence of coarse material are proof of stable aeolian transport conditions and a dry and hot climate.

Layers L6 through L11 can be dated by the brick platform covering them in squares 2101–2102 (on the platform, see Myśliwiec 2002b; 2005a) [cf. *Figs 1, 9*]. The platform should be dated in all probability to the early Nineteenth Dynasty, hence the maximum time range for the formation of these layers should be assumed as being from the end of the Sixth through of the Nineteenth Dynasty.

CONCLUSIONS

Observations of strata making up the exposures of Phase I have led to some general conclusions concerning the functioning of the Lower Necropolis in the hundred years between 2700 and 2600 BC. This regards in particular the unfinished tomb with ramp discovered in the western part of sector 2002 (on this tomb, cf. Myśliwiec 2005a; 2005b; 2006b, Welc 2007). Assuming that the dating of the structure to the end of Second or beginning of the Third Dynasty is correct (Myśliwiec 2005a; 2007; Welc 2007; Welc 2009: 177–178; see also suggestion of a later dating to the close of the Third and early Fourth Dynasty, Kuraszkiewicz 2009: 170), the cessation of work on this hypogeum may be connected with its unfortunate location on the slope and in the line of concentrated flows from the east, from the complex of Netjerykhet. In effect, the planned tomb would have been threatened by frequent flooding and filling with recurring mud and rubble flows.

Pebble long-axis analyses carried out for the *upper red layer* (L3) and the *lower red layer* (L5) have contributed important data on the ground relief in the area at the time. The mud and rubble flows which are responsible for the formation of these layers flowed mainly from the east. This means that there was no physical barrier in that direction. This refutes the theory that the so-called Western Massif, the west face of which is found just beyond the enclosure wall, was constructed earlier than the Step Pyramid complex.[5]

Had such a monumental structure existed in this location before the time of the Third Dynasty, the water-flow pattern in this part of the site would have been different from that recorded by the present research.

In summary, based on the analysis of deposits making up the profile of Phase II, it can be supposed that the Lower Necropolis went out of use mainly due to the effects of climatic changes which took place at the turn of the Old Kingdom and the First Intermediate Period. In the initial phase of these environmental changes, the climate was very humid and characterized by intensive rainfall. An extended period of intensive rainfall resulted in the destruction of the mastaba superstructures and penetration by the rainwater of at least some shafts which remained open after plundering. The waters stagnated in many seasonal reservoirs all over the area of the necropolis.

Under such conditions the necropolis could not have been used for burial purposes any longer. In successive stages, the climate became drier and characterized by heavy winds. No building activities took place within the confines of the study area until the appearance of the mud-brick platform, presumably in the beginnings of the Nineteenth Dynasty. The area of this necropolis started to be used intensively again for burials in the Ptolemaic age (cf. Myśliwiec 2002a; Myśliwiec *et alii* 2008: 11–13).

5 According to R. Stadelmann, the Western Massif is an independent architectural structure predating the building of the Step Pyramid, cf. Stadelmann 1985. New ceramological analyses have shown, however, that the westernmost projection of the Western Massif was built or at least rebuilt during the reign of Netjerykhet, see T.I. Rzeuska and F. Welc, in this volume.

REFERENCES

Ćwiek, A.

2000 The stratigraphy of West Saqqara. Preliminary remarks, *PAM* XI [=*Reports 1999*], 109–117

De Wit, H.E.

1993 The evolution of the Eastern Nile Delta as a factor in the development of human culture [in:] L. Krzyżaniak, M. Kobusiewicz, J. Aleksander (eds), *Environmental Change and Human Culture in the Nile Basin and Northern Africa Until the Second Millennium B.C.*, Poznań, 305–320

El-Qady, G., Sakamoto, Ch., Ushijima, K.

1999 2-D inversion of VES data in Saqqara archaeological area, Egypt, *Earth Planets Space*, 51, 1093

Horowitz, A.

1979 *The Quaternary of Israel*, New York: Academic Press

Kuraszkiewicz, K.

2007 Remarks on the development of the Old Kingdom Necropolis, *PAM* XVII [=*Reports 2005*], 169–175

2009 More remarks on late Old Kingdom mastabas west of the Step Pyramid, *PAM* XVIII [=*Reports 2006*], 165–173

Mycielska-Dowgiałło, E., Woronko, B.

1998 Analysis of mineral deposits in the Northern Wall of Pit I, *PAM* IX [=*Reports 1997*], 106–115

1999 Genetic-climatic interpretation of mineral deposits uncovered in section N and sections perpendicular to it, *PAM* X [=*Reports* 1998], 107–112

Mycielska-Dowgiałło, E., Szafrański, Z.E., Woronko, B.

1999 Reconstruction of morpho-dynamic processes during the last 4700 years period in the archaeological site (Area I) at Saqqara (Egypt), *Geoarqueologia i Quaternari Litoral. Memorial M.P. Fumanal*, València, 167–178

Myśliwiec, K.

2002a The Ptolemaic Period Cemetery in West Saqqara, [in:] *A Tribute to Excellence. Studies Offered in Honor of E. Gaál, U. Luft and L. Török* [=*Studia Aegyptiaca* 17], Budapest, 349–359

2002b West Saqqara. Excavations 2001, *PAM* XIII [=*Reports 2001*], 135–138

2005a Eine geheimnisvolle Rampe und Plattform an der Westseite der Pyramide des Djoser, *Sokar* 11/2, 6–7

2005b West Saqqara 2004, *PAM* XVI [=*Reports 2004*], 152

2006a "Dry Moat" west of the Netjerykhet enclosure [in:] M. Barta (ed.), *The Old Kingdom Art and Archaeology, Proceedings of the Conference Held in Prague, May 31–June 4, 2004*, Prague: Czech Institute of Egyptology, Charles University in Prague and Academia, 233–237

2006b Saqqara. Archaeological Activities, 2005, *PAM* XVII [=*Reports 2005*], 160–168

2007 Saqqara [in:] *Seventy Years of Polish Archaeology in Egypt*, Warsaw: PCMA, University of Warsaw, 79–81

Myśliwiec, K., Kuraszkiewicz, K., Czerwik, D. Rzeuska, T.I., Kaczmarek M., Kowalska, A., Radomska, M., Godziejewski, Z.

2004 *The Tomb of Merefnebef*, *Saqqara* I, Warsaw: ZAŚ PAN and Neriton

Myśliwiec, K. e*t alii*

2008 *The Upper Necropolis, Saqqara* III *, Part* I, Warsaw: ZAŚ PAN and Neriton

Rzeuska, T. I., Welc, F.

2010 Some remarks on the Western Massif in the Step Pyramid complex, *PAM* XIX [=*Reports 2007*], 209–214

Said, R.

1962 *The Geology of Egypt*, Amsterdam–New York: Elsevier

Stadelmann, R.

1985 Die Oberbauten der Königsgräber der 2. Dynastie in Sakkara, *Mélanges Mokhtar* II [=*BdE* 97], Cairo: IFAO, 295–307

Swelim, N.

1988 The Dry Moat of the Netjerykhet complex [in:] J. Baines, T.G.H. James, A. Leahy and A.F. Shore (eds), *Pyramid Studies and Other Essays Presented to I.E.S. Edwards*, London: Egypt Exploration Society, 12–22

2006 Dry Moat. The south rock wall of the Inner South Channel [in:] E. Czerny, I. Hein, H. Hunger, D. Melman, A. Schwab (eds), *Timelines: Studies in Honour of Manfred Bietak* [=*Orientalia Lovaniensia Analecta* 149], Louvain-la-Neuve: Peeters, 363–376

Szafrański, Z.E.

1999 West Saqqara, Observations on stratigraphy. North-west part of area I/E-F (former Pit I/E-F), *PAM* X [=*Reports 1998*], 91–96

Welc, F.

2007 Exploration of an Archaic (?) funerary structure in Sector 2002, *PAM* XVII [=*Reports 2005*], 176–181

2009 Some remarks on the early Old Kingdom structures adjoining on the west enclosure wall of the Netjerykhet funerary complex, *PAM* XVIII [=*Reports 2006*], 174–179